International Journal of Population Data Science

Journal Website: www.ijpds.org

Childbirth-Related Hospital Burden by Socioeconomic Status in a Universal Health Care Setting

Mah, SM[1*], Sanmartin, C[2], Harper, S[1], and Ross, NA[1]

Submission History

Submitted:	11/09/2017
Accepted:	16/02/2018
Published:	05/07/2018

[1]McGill University
[2]Statistics Canada

Abstract

Introduction
Hospital utilization varies across socioeconomic and demographic strata in Canada, a country with a universal health care system. Rates of adverse birth outcomes are known to differ among women of high and low socioeconomic status (SES), but less is known of the excess hospital burden related to SES over the course of childbirth across Canadian provinces.

Objective
To examine length of stay and risk of hospitalization surrounding delivery, relative to women's socio-demographic characteristics.

Methods
A population-based record linkage between the Canadian Community Health Survey (CCHS) years 2005-2011 and the Discharge Abstract Database (DAD) allowed the tracking of hospital utilization for linked survey respondents between 2005 and 2011. Hourly length of stay for delivery, risk of readmission, and risk of admission prior to delivery was modeled by socio-demographic factors, controlling for other clinical and individual-level characteristics.

Results
There were 21,914 complete delivery records from 15,458 female CCHS respondents who agreed to link and share their information. Average length of stay (for both vaginal and Caesarian deliveries) dropped over the study period from 67.86 hours in 2005 to 59.37 hours in 2011. In multivariate analyses, women with the lowest income had on average, two-hour longer stays for vaginal delivery as compared to high-income women (IRR 1.04, 95% CI 1.00-1.08) and higher risk of admission prior to delivery (OR 1.43, CI 1.13-1.81). Low-income women, Aboriginal women and women living in rural areas were also at elevated risk for longer hospital stays and for hospital admission prior to delivery. There was no consistent socioeconomic patterning of hospital burden for Caesarian deliveries.

Conclusion
The length of hospital stays for childbirth has declined in Canada. Length of stay remains modestly longer, and risk of hospitalization in the perinatal period higher, for low income women, Aboriginal women and rural women. The absence of egregious income-related differences in hospital burden related to childbirth is reassuring for the equity goals of the Canadian health care system. The persistence of marginally longer, and in turn, costlier visits for low-income and Aboriginal women before and during delivery is, however, suggestive that resources targeted to the prenatal period might be highly cost-effective if they achieve population-wide reductions in length of stay and hospitalization in the perinatal period.

Introduction

Canada's universal healthcare system is inspired by the goal of ensuring equal access to health services regardless of the user's ability to pay. The theoretical absence of barriers to health care makes for an ideal setting to study the socio-economic differences in health that remain. Canadian studies reveal disparities in disease prevalence and cumulative health care costs among patients of low socioeconomic status (SES) as compared with those of higher SES (1, 2). Delivery in hospital is one of the most common and routine medical procedures. As such, it is a good indicator of health equity and performance. Recent data linkage initiatives have made possible large-scale individual-level studies of SES and health care utilization.

It is well-established that the perinatal period is sensitive to socioeconomic deprivation (3). Previous work suggests that

*Corresponding Author:
Email Address: sarah.mah@mail.mcgill.ca (SM Mah)

http://dx.doi.org/10.23889/ijpds.v3i1.418
July 2018 © The Authors. Open Access under CC BY-NC-ND 4.0 (https://creativecommons.org/licenses/by-nc-nd/4.0/deed.en)

some Canadian success has been achieved in providing highly accessible obstetric services to women (4). What is less clear is whether remaining socioeconomic differences in child and maternal health outcomes in Canada (5-9) (that are presumably not access-related) necessarily translate into socioeconomic variations in hospital burden.

Previous studies for child and maternal health have shown generally higher rates of readmissions in low-SES women and infants (10-12), in addition to elevated maternal (13, 14) and infant hospitalization (15-18). However, these analyses are often limited to single-province datasets bearing regional health care contexts. Also unknown are whether admissions prior to delivery display similar social patterning. Disentangling delivery utilization patterns at a national scale, focusing on individual-level SES, is useful from an economic and health policy perspective, and could give us insight into the potential costs of social inequality.

Our goal was to determine whether socio-demographic patterns are seen for hospital burden related to childbirth in Canada. We retrieved a population-based sample of female survey respondents who gave birth in Canada between 2005 and 2011, and evaluated associations between SES and demographic factors, hourly length of stay for delivery, and risk of hospital admission surrounding delivery.

Methods

Data sources

This study employed record linkage between two national data sources - the Canadian Community Health Survey (CCHS) and the Discharge Abstract Database (DAD). The CCHS is maintained by Statistics Canada, and the DAD is managed by the Canadian Institute for Health Information (CIHI). Details of the creation of the linked database, validation results and protocol for the protection of privacy of respondents has been described in detail elsewhere (19).

The CCHS is a repeated cross-sectional survey that collects self-reported information related to health status, behaviors and conditions from the Canadian population. Each two-year survey cycle is composed of 130,000 Canadians who are 12 years of age or older, drawn from private dwellings across the country. The survey covers 98% of the population, but importantly, excludes those living on reserves and other Aboriginal settlements, full-time members of the Canadian Forces, institutionalized individuals, and those living in the Quebec health regions of Région du Nunavik and Région des Terres-Cries-de-la-Baie-James (20). The overall response rates to CCHS cycles 3.1, 4.1, 2009, 2010, and 2011 were 79%, 76%, 73%, 71.5%, and 69.8%, respectively. Female CCHS respondents from these two cycles were pooled to achieve the highest sample size possible for this analysis. For the small number of individuals (n=115) that responded to multiple cycles/years of the CCHS, the survey response that was timed closest to their first delivery in the dataset was used.

The DAD is an administrative hospital database that records all separations from Canadian acute care institutions. Acute care hospitals keep provincially standardized charts and records, but also submit abstracts with key requested fields to CIHI for incorporation into the DAD. These key fields include discharges, deaths, sign-outs, and transfers, and contains administrative, clinical, and limited demographic data. Records for all provinces (except the province of Quebec, as Quebec hospital records are not available in the DAD) were probabilistically linked by Statistics Canada for the vast majority of CCHS respondents that agreed to link and share their information (85% averaged across survey years). DAD fiscal years 2005 to 2011 were included in this analysis. The record linkage procedure was similar to previous studies (21). Linked files were appended, merged, and analyzed using Stata version 12 (StataCorp LC, College Station, Tex). We used an unweighted approach, pooled linked records across different years, and treated these data like an epidemiological cohort. All analyses were conducted under project numbers 14-HAD-MCG-4064 and 15-HAD-MCG-4802 at the McGill University site of the Canadian Research Data Centre Network, a secure laboratory which provides access to micro-data holdings of Statistics Canada, Canada's national statistical agency. Statistics Canada has in place a detailed protocol for protection of respondent confidentiality that was followed in these analyses (22).

Study population

Our population of interest was female CCHS respondents from who had singleton deliveries between fiscal years 2005 and 2011. Principal diagnoses were recorded using the Tenth Canadian revision of the International Classification of Diseases and related Health Problems (ICD-10-CA). and those indicating a singleton live birth occurred (23) were used to identify admissions of interest (Supplementary Table 1).

Explanatory & outcome measures

The primary explanatory variable of interest was socioeconomic status as measured by total household income from all sources, and was adjusted for household size in each model. We used a dose-response approach to evaluate the relationship between income and length of stay (also adjusted for household size), and found optimal contrasts in length of stay between those with incomes ranging from 0-$19,999, $20,000-$49,999, and $50,000 or more (Supplemental Figure 1). Maternal educational attainment is another measure of socioeconomic status in studies of childbirth that is relatively stable and independent of income (24). However, education may not be completed by the time women begin having children, making it an unreliable proxy of SES for younger women in the study. Moreover, having children may also act as a barrier to women's educational attainment, or delay education until after childbirth and rearing. For these reasons, the focus of our paper is on income as the primary marker of socioeconomic status and material resources.

Based on previous evidence of their association with adverse maternal health and birth outcomes, Aboriginal status, urban-rural residence, immigrant status, and marital status were other socio-demographic factors included in the models. We also adjusted for delivery-specific factors, including maternal age at delivery, fiscal year, and primiparity (first-time pregnancy). Primiparity was not reported consistently in the DAD and so a proxy variable was constructed using information that was available in the DAD on previous births. Information from

the DAD was combined with a CCHS variable that reported having a living arrangement with children, as well as preceding births recorded in our dataset (Supplementary Table 2).

The principal outcome of interest was length of stay. Delivery in hospital is brief, highly standardized, and routine. Utilization patterns may appear subtle and difficult to interpret when expressed as fractions of days. Therefore, hourly contrasts may be more meaningful and easier to interpret. Administrative hospital data often contains inaccurately recorded admission and discharge times, or these times are not recorded at all. Often, coders are left to fill in artificial times. To assess whether this was the case for time variables in the DAD, we scanned the dataset's timestamp frequencies for a disproportionately high number of admissions or discharges occurring at noon hour, midnight, and rounded hours. We confirmed that, while there were disproportionate discharge times by the half-hour and by tens of minutes, there were no missing values or drastic spikes at noon, midnight, or any particular hour for birth events (Supplementary Table 2), and considered these variables suitable for hourly analysis. Our secondary outcomes of interest included the risk of admission within 30 days prior to and after a hospital visit for delivery.

Statistical analyses

Length of stay was modeled in hours as a count variable using negative binomial regression. Risk of admission 30 days prior to and 30 days after delivery were modeled using logistic regression. All analyses were stratified by mode of delivery (vaginal and Caesarean). Robust and clustered standard errors were used to account for the presence of multiple deliveries from a single woman. Only cases with complete information were included in the analysis. Explanatory variables were selected a priori for inclusion in the regression models, based on their relevance to the relationship between socioeconomic status and hospital utilization for delivery in the literature. An interaction term between Aboriginal status and rural-urban residence was tested for every model, however, no evidence of interaction was observed and was therefore not reported.

Results

Maternal characteristics

A total of 24,733 deliveries in hospital were detected for linked female CCHS respondents using birth-related ICD codes in the DAD (n=17,600 women). 2,005 respondents (11.56%) were missing data, and were primarily those who did not answer the income component of the survey (1,931 respondents). Income non-responders tended to be younger and single (Supplementary Table 3).

We took a conservative approach in our use of the linked dataset, and excluded a low number of individuals whose sex and/or year of birth did not match because these were key variables in the linkage process. After exclusion of these individuals, as well as those individuals with missing data, the final sample for complete case analysis was 21,914 deliveries attributed to 15,458 women (Table 1, Supplementary Figure 3). Deliveries occurred between March 28th, 2005 and March 31st, 2012 (fiscal year 2011), inclusive. Average maternal age at delivery was 29.3 years. Adolescent birth rates were over four-fold higher for Aboriginal girls (16.31%) than for non-Aboriginal girls (3.41%).

Delivery characteristics

The consistency in clinical characteristics of this sample with national childbirth trends suggests population representativeness for this linkage (Table 2). Average length of stay for vaginal (2.08 days) and Caesarian (3.71 days) deliveries were nearly identical to those reported by national health reporting agencies (25, 26). Delivery by C-section accounted for 27% of live singleton births, which is also similar to estimates from national acute hospitalization data between 2001 and 2011 (27). Both maternal readmissions within 30 days of discharge for delivery and maternal admission within 30 days prior to admission for delivery were relatively rare, taking place for 1.4% and 4.3% of all deliveries, respectively. The overall average length of stay for deliveries declined over the study period from 2.72 days in 2005 to 2.35 days by 2011, which amounts to a difference of over eight hours. This follows the trajectory of national perinatal health secular trends seen from 1995 to 2005 (26).

Modelling length of stay in hours by SES

Socioeconomic differences by household income were seen for length of stay in both vaginal and Caesarian deliveries, particularly for those in the lowest-income group (Table 3, full results summarized in Supplementary Table 4). For vaginal deliveries, the lowest income women stayed approximately two hours longer in hospital than the highest income women [IRR 1.04, 95% CI 1.00-1.08], even after adjusting for individual-level factors. There was little difference in length of stay between middle-income and high-income women [IRR 1.00, 95% CI 0.97-1.03]. When investigating women undergoing Caesarian section, middle-income women emerged as those with the longest length of stay at over 10 hours longer than high-income women [IRR 1.12, 95% CI 1.04-1.19], while low-income women exhibited similar lengths of stay to high-income women.

Modelling risk of admission before and after delivery by SES

Risk of pre-delivery admission was 4% for high income women, 5% for middle-income women [OR 1.46, 95% CI 1.25-1.70] and 6% for low income women [OR 1.80, 95% CI 1.48-2.20] in unadjusted models (Table 4). This graded pattern was attenuated but still evident in fully adjusted models where the risk was elevated for middle-income [OR 1.31, 95% CI 1.11-1.54] and low-income women [OR 1.43, 95% CI 1.13-1.81] compared with high income women. There was no conclusive difference in risk of admission after delivery by income level for vaginal deliveries. Weaker evidence was seen for an association between income and risk of readmission after a Caesarian section (Table 5). The predicted risk of readmission was two-fold for low-income women compared with high-income women in unadjusted models [OR 2.35, 95% CI 1.44-3.83], but diminished when adjusted for individual-level factors [OR 1.80, 95% CI 0.98-3.27].

Table 1: Maternal Characteristics (n = 15,458)

	Frequency	(%)
Maternal age*		
≤19 y.o.	729	5
20-34 y.o.	12123	78
≥35 yo	2606	17
Number of deliveries		
1	9986	65
2	4592	30
3+	880	6
Income		
Low	1586	10
Middle	3884	25
High	9988	65
Rural area of residence	3760	24
Marital status un-partnered	4118	27
Aboriginal Status	1563	10
Recent immigrant (10 years)	1089	7
Province of residence		
Ontario	6130	40
Prince Edward Island	319	2
Nova Scotia	664	4
New Brunswick	705	5
Newfoundland Labrador	549	4
Manitoba	1158	7
Saskatchewan	1311	8
Alberta	2085	13
British Columbia	1891	12
Territories	646	4

Data Sources: CCHS years 2005-2011; DAD fiscal years 2005-2011.
*Maternal age at first delivery listed in the dataset, pertaining to those women who had multiple births in hospital between 2005 and 2011.

Table 2: Delivery characteristics for 21,914 deliveries (n=15,458)

	Frequency	(%)	Average length of stay in days	Average length of stay in hours
Fiscal year				
2005	3333	(15)	2.72	67.86
2006	3427	(16)	2.6	65.09
2007	3398	(16)	2.62	65.67
2008	3237	(15)	2.52	63.38
2009	3104	(14)	2.38	60.03
2010	2809	(13)	2.43	61.20
2011	2606	(12)	2.35	59.37
Mode of delivery				
Vaginal	15902	(73)	2.08	52.59
Caesarian	6012	(27)	3.71	92.19
Maternal readmission*	306	(1)	3.63	89.27
Pre-delivery admission**	936	(4)	3.51	86.46
All Deliveries	21914		2.53	63.45

Data source: DAD 2005-2011.
*Represents the number of deliveries that had a maternal readmission within 30 days after delivery, and average length of stay of those preceding deliveries.
**Represents the number of deliveries that had a maternal admission within 30 days prior to delivery, and average length of stay of those subsequent deliveries.

Utilization patterns associated with other factors

We observed modest but consistently longer length of stay (for vaginal delivery only) [IRR 1.07, 95% CI 1.03-1.10] and risk of pre-delivery admission [OR 1.87, 95% CI 1.57-2.24] for Aboriginal women0, even after adjusting for other factors [IRR 1.06, 95% CI 1.02-1.10; OR 1.34, 95% CI 1.09-1.67]. Higher risk of readmission for Aboriginal women was seen before adjusting for covariates, and after adjusting for covariates with some attenuation in the estimated effect sizes. Longer length of stay and higher risk of admissions surrounding delivery were seen in un-partnered women before adjusting for covariates, but only persisted for length of stay, predicted to be 1.75 hours longer than for partnered women in the adjusted model [IRR 1.03, 95% CI 1.00-1.06].

While subtle sociodemographic patterns were observed after adjusting for multiple individual-level factors, the strongest contrasts in hospital utilization were systemically seen between vaginal and Caesarian deliveries, among provinces/territories, as well as between women who were giving birth for the first for the first time and those who had previously given birth (Supplementary Tables 4-6). The largest variations for vaginal delivery occurred between provinces/territories, with the longest predicted length of stay at 3.22 days [77.29 hours, 95% CI 72.64-81.94] seen in in Newfoundland Labrador (after adjusting for individual-level factors in fully adjusted models), and the shortest length of stay seen for Alberta at 1.84 days [44.24 hours, 95% CI 42.74-45.74]. Urban–rural differences were seen for length of stay related to vaginal deliveries, with a predicted three-hour longer stay for women living in rural areas as compared to those living in urban areas [IRR 1.05, 95% CI 1.02-1.09], but lower risk of readmission for rural women after Caesarian deliveries in adjusted models [OR 0.49, 95% CI 0.30-0.80]. Women giving birth for the first time stayed significantly longer in hospital than those who had previously giving birth, with a predicted 14.71-hour longer stay for vaginal deliveries [IRR 1.31, 95% CI 1.27-1.34], and a 6.44-hour longer stay for Caesarian deliveries [IRR 1.19, 95% CI 1.13-1.25]. However, there was little evidence of elevated risk of admission before or after delivery for primiparous women.

Discussion

Low-income women in Canada have modestly longer stays in hospital in Canada (approximately 2 hours longer, on average, for vaginal deliveries) than more affluent women. Length of stay in hospital for Caesarian deliveries was not generally graded by household income, although the risk of maternal readmission was higher in low-income women following Caesarian, which may signal a gap in care for low-income women over the wider delivery and postnatal period. Delivery by Caesarian-section is considered major surgery, requires greater recovery time (indicated by, on average, longer hospital stays relative to vaginal deliveries) and possibly material and social resources, which might explain some of the differences. Both low- and middle- income women were at higher risk of having an admission to hospital prior to delivery than high income women. These findings are in line with past research showing a tendency for lowest income groups to have longer hospital stays and higher overall hospital burden (12-14, 17, 18).

Length of stay in hospital for childbirth was longer for Aboriginal women and Aboriginal women were at elevated risk of pre-delivery admission and readmission to hospital after Caesarian deliveries. Aboriginal women and girls also had dra-

Table 3: Incidence rate ratios and marginal estimates of length of stay (LOS) in hours

Vaginal Delivery (n = 15,902)						
	Unadjusted			Adjusted**		
	IRR [95%CI]	*P*	LOS [95%CI]	IRR [95%CI]	*P*	LOS [95%CI]
Income						
High	1.00		52.09 [51.28, 52.90]	1.00		52.31 [51.51, 53.11]
Middle	1.01 [0.99, 1.04]	0.348	52.80 [51.55, 54.05]	1.00 [0.97, 1.03]	0.822	52.49 [51.20, 53.78]
Low	1.06 [1.02, 1.09]	0.003*	54.99 [53.22, 56.76]	1.04 [1.00, 1.08]	0.039*	54.53 [52.61, 56.44]
Aboriginal Status						
No	1.00		52.20 [51.51, 52.88]	1.00		52.24 [51.60, 52.89]
Yes	1.07 [1.03, 1.10]	<0.001*	55.68 [53.88, 57.48]	1.06 [1.02, 1.10]	0.003*	55.41 [53.36, 57.46]
Geography						
Urban	1.00		51.46 [50.74, 52.19]	1.00		51.87 [51.17, 52.57]
Rural	1.08 [1.05, 1.12]	<0.001*	55.82 [54.48, 57.17]	1.05 [1.02, 1.09]	<0.001*	54.64 [53.21, 56.07]
Marital status						
Partnered	1.00		51.65 [50.89, 52.41]	1.00		52.15 [51.38, 52.92]
Not-partnered	1.07 [1.04, 1.10]	<0.001*	55.37 [54.20, 56.54]	1.03 [1.00, 1.06]	0.033*	53.89 [52.58, 55.19]
Immigrant status						
No	1.00		52.77 [52.12, 53.42]	1.00		52.54 [51.91, 53.16]
Yes	0.95 [0.89, 1.01]	0.106	50.09 [46.99, 53.19]	1.02 [0.96, 1.09]	0.531	53.59 [50.33, 56.84]
Caesarian Delivery (n = 6,012)						
	Unadjusted			Adjusted**		
	IRR [95%CI]	*P*	LOS [95%CI]	IRR [95%CI]	*P*	LOS [95%CI]
Income						
High	1.00		89.55 [87.34, 91.75]	1.00		89.70 [87.37, 92.02]
Middle	1.12 [1.05, 1.20]	0.001*	100.70 [94.50, 106.91]	1.12 [1.04, 1.19]	0.001*	100.07 [94.05, 106.10]
Low	1.00 [0.94, 1.06]	0.95	89.38 [84.81, 93.96]	1.00 [0.93, 1.08]	0.984	89.76 [84.18, 95.34]
Aboriginal Status						
No	1.00		92.02 [89.74, 94.30]	1.00		91.90 [89.69, 94.12]
Yes	1.02 [0.96, 1.08]	0.492	93.94 [88.91, 98.97]	1.04 [0.97, 1.10]	0.263	95.13 [89.76, 100.50]
Geography						
Urban	1.00		90.72 [88.57, 92.86]	1.00		91.34 [89.17, 93.51]
Rural	1.07 [1.00, 1.14]	0.04*	96.91 [91.23, 102.59]	1.04 [0.98, 1.10]	0.235	94.82 [89.45, 100.20]
Marital status						
Partnered	1.00		90.82 [88.58, 93.06]	1.00		91.02 [88.71, 93.34]
Not-partnered	1.07 [1.00, 1.13]	0.04*	96.79 [91.42, 102.17]	1.06 [0.98, 1.13]	0.127	96.04 [90.20, 101.88]
Immigrant status						
No	1.00		92.49 [90.27, 94.71]	1.00		92.28 [90.11, 94.46]
Yes	0.95 [0.88, 1.04]	0.26	88.21 [81.24, 95.17]	0.98 [0.90, 1.07]	0.711	90.82 [83.46, 98.19]

Data Sources: CCHS years 2005-2011; DAD fiscal years 2005-2011.

* $P < 0.05$

** adjusted models include the five socio-demographic variables in addition to household size, primiparity, province of delivery, year of delivery, and maternal age at delivery.

Table 4: Odds ratios and risks of maternal admission within 30 days before delivery

Vaginal Delivery (n = 15,902)						
Risk of pre-delivery admission for all deliveries (n=21,914)						
	Unadjusted			Adjusted**		
	OR [95%CI]	P	Predicted risk [95%CI]	OR [95%CI]	P	Predicted risk [95%CI]
Income						
High	1.00		0.04 [0.03, 0.04]	1.00		0.04 [0.03, 0.04]
Middle	1.46 [1.25, 1.70]	<0.001*	0.05 [0.05, 0.06]	1.31 [1.11, 1.54]	0.002*	0.05 [0.04, 0.05]
Low	1.80 [1.48, 2.20]	<0.001*	0.06 [0.05, 0.07]	1.43 [1.13, 1.81]	0.003*	0.05 [0.04, 0.05]
Aboriginal Status						
No	1.00		0.04 [0.04, 0.04]	1.00		0.04 [0.04, 0.04]
Yes	1.87 [1.57, 2.24]	<0.001*	0.07 [0.06, 0.08]	1.34 [1.09, 1.67]	0.007*	0.05 [0.04, 0.06]
Geography						
Urban	1.00		0.04 [0.04, 0.04]	1.00		0.04 [0.04, 0.05]
Rural	1.16 [1.00, 1.35]	0.056	0.05 [0.04, 0.05]	1.01 [0.86, 1.18]	0.914	0.04 [0.04, 0.05]
Marital status						
Partnered	1.00		0.04 [0.04, 0.04]	1.00		0.04 [0.04, 0.05]
Not-partnered	1.24 [1.06, 1.44]	0.006*	0.05 [0.04, 0.06]	0.97 [0.81, 1.17]	0.764	0.04 [0.04, 0.05]
Immigrant status						
No	1.00		0.04 [0.04, 0.05]	1.00		0.04 [0.04, 0.05]
Yes	0.51 [0.36, 0.72]	<0.001*	0.02 [0.02, 0.03]	0.62 [0.43, 0.88]	0.007*	0.03 [0.02, 0.04]
Primiparous						
No	1.00		0.04 [0.04, 0.05]	1.00		0.04 [0.04, 0.05]
Yes	0.88 [0.76, 1.01]	0.063	0.04 [0.03, 0.04]	1.04 [0.89, 1.23]	0.598	0.04 [0.04, 0.05]

Data Sources: CCHS years 2005-2011; DAD fiscal years 2005-2011.
* $P < 0.05$
** adjusted models include the five socio-demographic variables in addition to household size, primiparity, province of delivery, year of delivery, and maternal age at delivery.

Table 5: Odds ratios and risks of maternal admission within 30 days before delivery

Risk of readmission for vaginal delivery (n = 15,902)						
	Unadjusted			Adjusted**		
	OR [95%CI]	P	Predicted risk [95%CI]	OR [95%CI]	P	Predicted risk [95%CI]
Income						
High	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Middle	1.29 [0.92, 1.80]	0.15	0.01 [0.01, 0.02]	1.16 [0.80, 1.67]	0.44	0.01 [0.01, 0.02]
Low	1.42 [0.91, 2.21]	0.13	0.01 [0.01, 0.02]	1.08 [0.64, 1.81]	0.77	0.01 [0.01, 0.02]
Aboriginal Status						
No	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Yes	1.86 [1.26, 2.73]	0.002*	0.02 [0.01, 0.03]	1.58 [0.97, 2.56]	0.07	0.02 [0.01, 0.02]
Geography						
Urban	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Rural	1.14 [0.82, 1.58]	0.44	0.01 [0.01, 0.02]	1.06 [0.75, 1.51]	0.74	0.01 [0.01, 0.02]
Marital status						
Partnered	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Not-partnered	1.38 [1.01, 1.89]	0.046*	0.01 [0.01, 0.02]	1.29 [0.89, 1.86]	0.18	0.01 [0.01, 0.02]
Immigrant status						
No	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Yes	1.01 [0.56, 1.82]	0.98	0.01 [0.01, 0.02]	1.16 [0.62, 2.17]	0.64	0.01 [0.01, 0.02]
Primiparous						
No	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Yes	1.00 [0.73, 1.36]	0.99	0.01 [0.01, 0.01]	1.17 [0.83, 1.66]	0.38	0.01 [0.01, 0.02]
Risk of readmission for Caesarian Delivery (n = 6,012)						
	Unadjusted			Adjusted**		
	OR [95%CI]	P	Predicted risk [95%CI]	OR [95%CI]	P	Predicted risk [95%CI]
Income						
High	1.00		0.02 [0.01, 0.02]	1.00		0.02 [0.01, 0.02]
Middle	1.42 [0.94, 2.14]	0.09	0.02 [0.02, 0.03]	1.22 [0.75, 1.99]	0.42	0.02 [0.01, 0.03]
Low	2.35 [1.44, 3.83]	0.001*	0.04 [0.02, 0.06]	1.80 [0.98, 3.27]	0.06	0.03 [0.02, 0.05]
Aboriginal Status						
No	1.00		0.02 [0.02, 0.02]	1.00		0.02 [0.02, 0.02]
Yes	2.12 [1.32, 3.40]	0.002*	0.04 [0.02, 0.06]	1.87 [1.12, 3.12]	0.017*	0.04 [0.02, 0.05]
Geography						
Urban	1.00		0.02 [0.02, 0.03]	1.00		0.02 [0.02, 0.03]
Rural	0.60 [0.37, 0.97]	0.036*	0.01 [0.01, 0.02]	0.49 [0.30, 0.80]	0.004*	0.01 [0.01, 0.02]
Marital status						
Partnered	1.00		0.02 [0.01, 0.02]	1.00		0.02 [0.02, 0.03]
Not-partnered	1.64 [1.12, 2.39]	0.01*	0.03 [0.02, 0.04]	1.04 [0.66, 1.64]	0.87	0.02 [0.01, 0.03]
Immigrant status						
No	1.00		0.02 [0.02, 0.03]	1.00		0.02 [0.02, 0.03]
Yes	0.54 [0.22, 1.33]	0.18	0.01 [0.00, 0.02]	0.64 [0.26, 1.60]	0.34	0.01 [0.00, 0.03]
Primiparous						
No	1.00		0.02 [0.02, 0.02]	1.00		0.02 [0.02, 0.02]
Yes	1.18 [0.83, 1.69]	0.36	0.02 [0.02, 0.03]	1.19 [0.80, 1.78]	0.40	0.02 [0.02, 0.03]

Data Sources: CCHS years 2005-2011; DAD fiscal years 2005-2011.

* $P < 0.05$

** adjusted models include the five socio-demographic variables in addition to household size, primiparity, province of delivery, year of delivery, and maternal age at delivery.

matically higher rates of teenage births (16.31%) compared with non-Aboriginal Canadian women and girls (3.41%) in our study. This is a trend seen in countries such as the United States (28) and Australia (29). Teenage pregnancy is a key indicator of population health that is more common in disadvantaged youth, and may influence social, educational, and economic opportunities later in life. For Aboriginal girls, the impacts are further exacerbated (30) by health and social disparities tied to the Canada's colonial history. The health status of Indigenous Canadians has continued to be poor despite Canada's universal health system. Perhaps a recent Lancet special series on Canada's health care leadership role describes this situation most aptly:

> *'As in other settler societies such as Australia, New Zealand, and the USA, Indigenous populations in Canada were colonised and marginalised. In the Canadian case, marginalisation took the forms of Indian Residential Schools, government-enforced relocation, and historically segregated Indian hospitals, to name a few. Three distinct and constitutionally recognised groups—First Nations, Inuit, and Métis—constitute 4.3% of the Canadian population and experience persistent health disparities relative to the non-Indigenous population, including higher rates of chronic disease, trauma, interpersonal and domestic violence, and suicide, as well as lower life expectancy and higher infant mortality rates. For example, Canada's infant mortality rate dropped by 80% from more than 27 deaths per 1000 livebirths in 1960, to five per 1000 livebirths on average in 2013. However, the estimated rate in Nunavut (the northern territory in which approximately 85% of the population is Inuit) was more than three times the national rate at 18 deaths per 1000 livebirths in 2013'*(31).

Our study represents one of the few multi-province health datasets that includes an Aboriginal identifier, and will enable future studies in Canadian Aboriginal health.

This study offers several methodological strengths. Previous hospital utilization studies on childbirth and SES have been conducted in single-provinces (10-18), whereas our sample has the diversity of multiple provincial health care settings. The availability of individual-level SES measures is a relatively uncommon advantage in population-level research on childbirth (7, 14). Area-based income, for example, is prone to attenuated trends due to non-differential misclassification bias (9), and these data represents an improvement upon area-based measures as a proxy for individual measures. By including an analysis of length of stay, as well as admissions before and after delivery, we were able to identify whether different factors were associated with differential resource utilization across the period of health care interaction for childbirth. Lastly, no utilization study on childbirth, to our knowledge, has examined hourly length of stay differences. We argue that hours are more appropriate for detecting differences in length of stay for deliveries than days, given that childbirth tends to be a relatively brief encounter compared to other hospitalizations.

A few points of caution remain. First, the data were drawn from a population-based survey that is not nationally representative, and comprise those respondents that agreed to link and share their data. All respondents from the province of Quebec were excluded as there are no hospitalization records for these individuals in the DAD. The CCHS also excludes Aboriginal individuals living on reserves, and does not capture the hospitalization experiences of this population. Second, non-responders of the income-related survey questions tended to be younger single women, and their exclusion from the analysis would result in an artificially higher SES sample with potentially better health status and lower health care needs. Non-responders were, however, 11% of the total eligible sample, which is lower than this survey's total non-response rates (32). Third, linkage between women and infant abstracts was not possible for this study. Socioeconomic patterning was still observed in maternal hospital burden for these data, which could be augmented by neonatal health records in the future. Finally, the study is sensitive to all limitations associated with the use of administrative data for health research (33) including uncertain data quality, missing data, reliability, a lack of control over the information collected and documentation. These factors likely led us to underestimate the extent of health care burden.

Our study implies systematic differences in length of stay in hospital for childbirth among women of different socio-demographic backgrounds, even after accounting for the strong influences of provincial context and primiparity. In Canada, hospital stays for childbirth are short by international comparison (34). Given an average length of stay of about two days, a measurable excess of two hours for vaginal deliveries, 10 hours for Caesarian deliveries, along with increased admissions in the prenatal and postnatal period for lower-income groups might translate to an extra time spent in hospital. The socio-demographic patterns seen here imply an appreciable excess cost at a population level, considering the average national cost of the least complicated in-hospital vaginal delivery was $1,882 in 2014-2015 (35). The subtle but observable elevation in length of stay for lower income women seen here raises the question as to whether additional reductions in length of stay could be achieved through resource redistribution to the prenatal period. A recent Canadian intervention study showed that giving expectant mothers an unconditional $81 per month in the prenatal period (granted by the provincial government to support healthy pregnancy outcomes) was followed by reductions in adverse birth outcomes and length of stay for vaginal deliveries in the province of Manitoba (36). Our study suggests that cash transfers to socioeconomically disadvantaged women during the prenatal period could be cost-effective if they achieve reductions in length of stay that are attributable to social factors.

Conclusion

Overall, the findings of this linked data study indicates that equity goals of the Canadian health care system, embedded in the Canada Health Act, are mainly being achieved for birth-related hospitalizations, as others have concluded. Canadian success in maternal health, while laudable, now motivates further assessment and mitigation of those modest but persistent socio-demographic differences in health and health care burden. Taken in the broader context of women's health, investment in preventive health policy warrants consideration

as a way to maintain Canada's generally positive outcomes observed during the perinatal period, and eventually improve health throughout the life course.

Acknowledgements

This work was supported by operating funds of the Canada Research Chairs Program. The authors would like to thank Michelle Rotermann for her assistance with this project. The conclusions of this paper reflect those of the authors and do not reflect those of Statistics Canada.

Statement on conflicts of interest

No conflicts of interest to disclose. However, we note that the views expressed in this article do not represent those of Statistics Canada.

Abbreviations

CCHS	Canadian Community Health Survey
CI	confidence interval
CIHI	Canadian Institute for Health Information
DAD	Discharge Abstract Database
IRR	incidence rate ratio
LOS	length of stay
SES	socioeconomic status

References

1. Lemstra M, Mackenbach J, Neudorf C, Nannapaneni U. High health care utilization and costs associated with lower socio-economic status: results from a linked dataset. Can J Public Health. 2009;100(3):180-3.

2. Disano J, Goulet J, Muhajarine N, Neudorf C, Harvey J. Social-economic status and rates of hospital admission for chronic disease in urban Canada. Can Nurse. 2010;106(1):24-9.

3. Larson CP. Poverty during pregnancy: Its effects on child health outcomes. Paediatrics & Child Health. 2007;12(8):673-7. https://doi.org/10.1093/pch/12.8.673

4. Joseph KS, Dodds L, Allen AC, Jones DV, Monterrosa L, Robinson H, et al. Socioeconomic status and receipt of obstetric services in Canada. Obstetrics and Gynecology. 2006;107(3):641-50. https://doi.org/10.1097/01.aog.0000201977.45284.3c

5. Blumenshine P, Egerter S, Barclay CJ, Cubbin C, Braveman PA. Socioeconomic disparities in adverse birth outcomes: a systematic review. Am J Prev Med. 2010;39(3):263-72. https://doi.org/10.1016/j.amepre.2010.05.012

6. Kramer M, Seguin L, Lydon J, Goulet L. Socio-economic disparities in pregnancy outcome: why do the poor fare so poorly? Paediatric and perinatal epidemiology. 2000;14(3):194-210. https://doi.org/10.1046/j.1365-3016.2000.00266.x

7. Joseph KS, Liston RM, Dodds L, Dahlgren L, Allen AC. Socioeconomic status and perinatal outcomes in a setting with universal access to essential health care services. Canadian Medical Association Journal. 2007;177(6):583-90. https://doi.org/10.1503/cmaj.061198

8. Auger N, Giraud J, Daniel M. The joint influence of area income, income inequality, and immigrant density on adverse birth outcomes: a population-based study. Bmc Public Health. 2009;9. https://doi.org/10.1186/1471-2458-9-237

9. Daoud N, O'Campo P, Minh A, Urquia ML, Dzakpasu S, Heaman M, et al. Patterns of social inequalities across pregnancy and birth outcomes: a comparison of individual and neighborhood socioeconomic measures. Bmc Pregnancy and Childbirth. 2015;14. https://doi.org/10.1186/s12884-014-0393-z

10. Martens PJ, Derksen S, Gupta S. Predictors of hospital readmission of Manitoba newborns within six weeks postbirth discharge: a population-based study. PEDIATRICS. 2004;114(3):708-13. https://doi.org/10.1542/peds.2003-0714-l

11. Sword WA, Watt S, Krueger PD, Soon-Lee K, Sheehan DD, Roberts JG, et al. Understanding newborn infant readmission: Findings of the Ontario mother and infant survey. Canadian Journal of Public Health-Revue Canadienne De Sante Publique. 2001;92(3):196-200.

12. Johnson D, Jin Y, Truman C. Influence of aboriginal and socioeconomic status on birth outcome and maternal morbidity. J Obstet Gynaecol Can. 2002;24(8):633-40. https://doi.org/10.1016/s1701-2163(16)30194-3

13. Kurtz Landy C, Sword W, Ciliska D. Urban women's socioeconomic status, health service needs and utilization in the four weeks after postpartum hospital discharge: findings of a Canadian cross-sectional survey. BMC Health Serv Res. 2008;8:203. https://doi.org/10.1186/1472-6963-8-203

14. Spicer A, Pinelli J, Saigal S, Wu YW, Cunningham C, DiCenso A. Health status and health service utilization of infants and mothers during the first year after neonatal intensive care. Adv Neonatal Care. 2008;8(1):33-41. https://doi.org/10.1097/01.anc.0000311015.56263.6f

15. Seguin L, Xu Q, Potvin L, Zunzunegui MV, Frohlich KL. Effects of low income on infant health. Cmaj. 2003;168(12):1533-8.

16. Ruth CA, Roos N, Hildes-Ripstein E, Brownell M. 'The influence of gestational age and socioeconomic status on neonatal outcomes in late preterm and early term gestation: a population based study'. Bmc Pregnancy and Childbirth. 2012;12. https://doi.org/10.1186/1471-2393-12-62

17. Thanh NX, Toye J, Savu A, Kumar M, Kaul P. Health Service Use and Costs Associated with Low Birth Weight–A Population Level Analysis. J Pediatr. 2015;167(3):551-6.e1-3. https://doi.org/10.1016/j.jpeds.2015.06.007

18. Wang C, Guttmann A, To T, Dick PT. Neighborhood Income and Health Outcomes in Infants How Do Those With Complex Chronic Conditions Fare? Archives of pediatrics & adolescent medicine. 2009;163(7):608-15. https://doi.org/10.1001/archpediatrics.2009.36

19. Sanmartin C, Decady Y, Trudeau R, Dasylva A, Tjepkema M, Fines P, et al. Linking the Canadian Community Health Survey and the Canadian Mortality Database: An enhanced data source for the study of mortality. Health Rep. 2016;27(12):10-8.

20. Statistics Canada. Canadian Community Health Survey - Annual Component (CCHS). 2008. [updated June 17 2008]. Available from: http://www23.statcan.gc.ca/imdb/p2SV.pl?Function=getSurvey&Id=29539.

21. Rotermann M. Evaluation of the coverage of linked Canadian Community Health Survey and hospital inpatient records. Health Rep. 2009;20(1):45-51.

22. Statistics Canada. Mitigation of Risk to Respondents of Statistics Canada's Surveys. 2010. [updated 5 July 2017]. Available from: https://www.statcan.gc.ca/eng/rdc/mitigation.

23. Canadian Institute for Health Information. Inpatient Hospitalizations, Surgeries and Childbirth Indicators in 2013–2014. 2015.

24. Luo Z-C, Wilkins R, Kramer MS, System FaIHSGotCPS. Effect of neighbourhood income and maternal education on birth outcomes: a population-based study. Canadian Medical Association Journal. 2006;174(10):1415-20. https://doi.org/10.1503/cmaj.051096

25. Canadian Institute for Health Information (CIHI). Giving Birth in Canada: The Costs. Ottawa, Canada; 2006.

26. Public Health Agency of Canada. Canadian Perinatal Health Report. In: Canada MoPWaGS, editor. 2008 ed. Ottawa 2008.

27. Public Health Agency of Canada. Perinatal Health Indicators for Canada 2013: a Report of the Canadian Perinatal Surveillance System. Ottawa, ON.; 2013.

28. Auger N, Gamache P, Adam-Smith J, Harper S. Relative and Absolute Disparities in Preterm Birth Related to Neighborhood Education. Annals of Epidemiology. 2011;21(7):481-8. https://doi.org/10.1016/j.annepidem.2011.03.012

29. Martin JA, Hamilton BE, Ventura SJ, Osterman M, Kirmeyer S, Matthews T, et al. Births: Final data for 2009 (National Vital Statistics Reports 60 (1)). Washington, DC: US Department of Health and Human Services. 2011.

30. Australian Bureau of Statistics, Statistics A-ABo, Australian Births d, Australian Government C. Australian Births, doc 3301.0. In: Statistics ABo, editor. Canberra: Australian Goverment; 1999.

31. Garner R, Guimond E, Senécal S. The socio-economic characteristics of First Nation teen mothers. The International Indigenous Policy Journal. 2013;4(1):9. https://doi.org/10.18584/iipj.2013.4.1.9

32. Paranjothy S, Broughton H, Adappa R, Fone D. Teenage pregnancy: who suffers? Arch Dis Child. 2009;94(3):239-45. https://doi.org/10.1136/adc.2007.115915

33. Wassimi S, McHugh NG, Wilkins R, Heaman M, Martens P, Smylie J, et al. Community Remoteness, Perinatal Outcomes and Infant Mortality among First Nations in Quebec. Open Womens Health J. 2010;4(1):32-8. https://doi.org/0.2174/1874291201004010032

34. Luo ZC, Wilkins R, Heaman M, Smylie J, Martens PJ, McHugh NG, et al. Birth outcomes and infant mortality among First Nations Inuit, and non-Indigenous women by northern versus southern residence, Quebec. J Epidemiol Community Health. 2012;66(4):328-33. https://doi.org/10.1136/jech.2009.092619

35. Bonikowska A, Helliwell JF, Hou F, Schellenberg G. An assessment of life satisfaction responses on recent Statistics Canada surveys. Social Indicators Research. 2014;118(2):617-43. https://doi.org/10.1007/s11205-013-0437-1

36. Jutte DP, Roos LL, Brownell MD. Administrative record linkage as a tool for public health research. Annu Rev Public Health. 2011;32:91-108. https://doi.org/10.1146/annurev-publhealth-031210-100700

37. Campbell OM, Cegolon L, Macleod D, Benova L. Length of Stay After Childbirth in 92 Countries and Associated Factors in 30 Low- and Middle-Income Countries: Compilation of Reported Data and a Cross-sectional Analysis from Nationally Representative Surveys. PLoS Med. 2016;13(3):e1001972. https://doi.org/10.1371/journal.pmed.1001972

38. Canadian Institute for Health Information. CIHI patient cost estimator 2016 [Available from: https://www.cihi.ca/en/spending-and-health-workforce/spending/patient-cost-estimator.]

39. Brownell MD, Chartier MJ, Nickel NC, Chateau D, Martens PJ, Sarkar J, et al. Unconditional Prenatal Income Supplement and Birth Outcomes. Pediatrics. 2016;137(6). https://doi.org/10.1542/peds.2015-2992

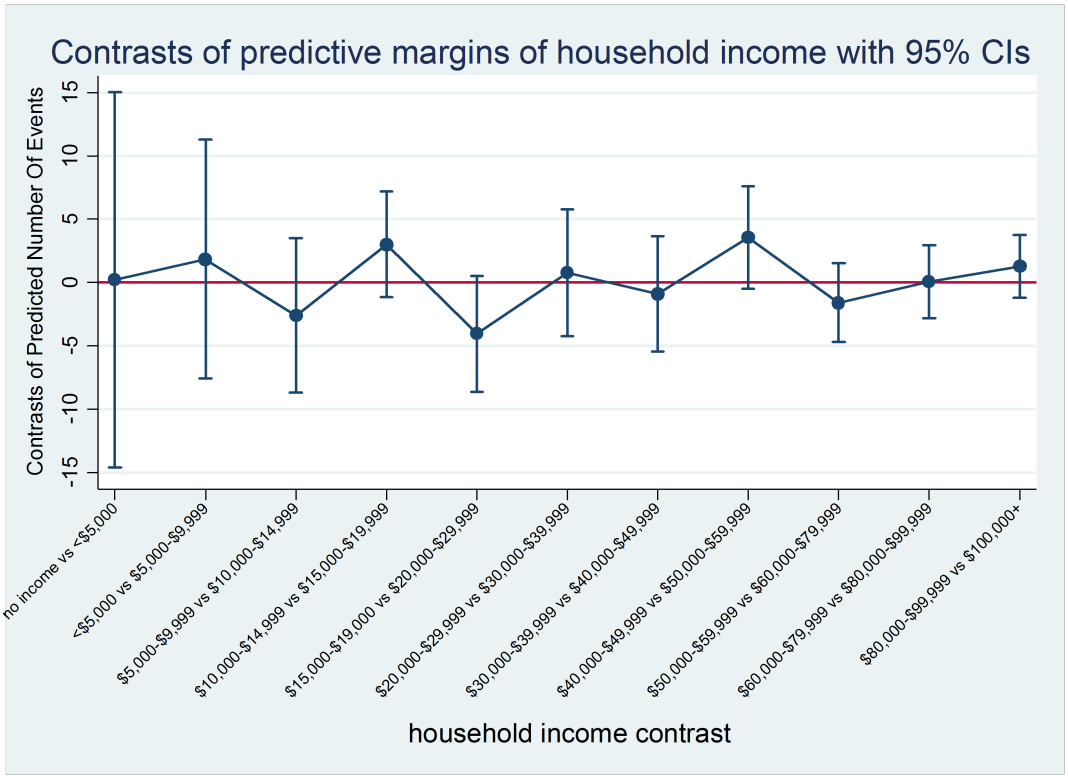
Supplementary Appendices

Supplementary Table 1: ICD-10-CA codes used to identify deliveries, and Case Mix Group CMG codes used to identify C-section births.

ICD-10-CA Delivery codes	Any one diagnosis code of O10 to O16, O21 to O29, O30 to O46, O48, O60 to O75, O85 to O92, O95 or O98 to O99, with a sixth digit of 1 or 2 -or- Z37
Case Mix Group (CMG) codes	CMG codes 536 and 537 were used to classify births as Caesarian deliveries CMG codes 538-545 were used to classify births as Vaginal deliveries

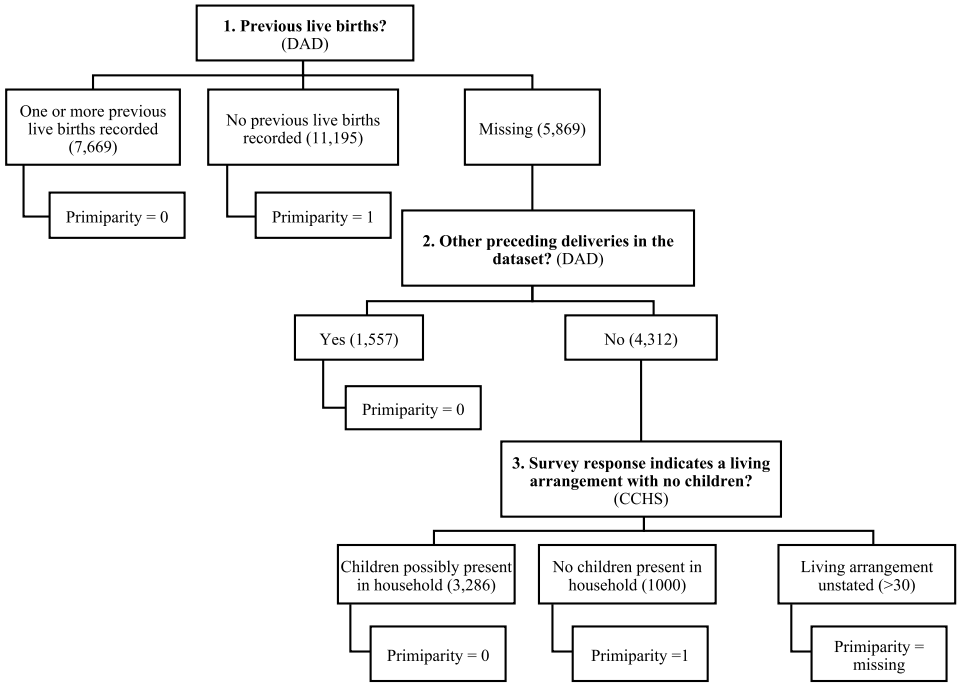
Source: Canadian Institute for Health Information (CIHI). Inpatient Hospitalizations, Surgeries and Childbirth Indicators in 2013–2014. 2015.

Supplementary Figure 1: Plot of predicted margins to identify optimal contrasts between adjacent income categories.



Data Source: Sample used complete case analysis from CCHS years 2005-2011.

Supplementary Figure 2: Flow chart detailing the algorithm used to identify primiparous women, using variables from the DAD and the CCHS related to having previous children.



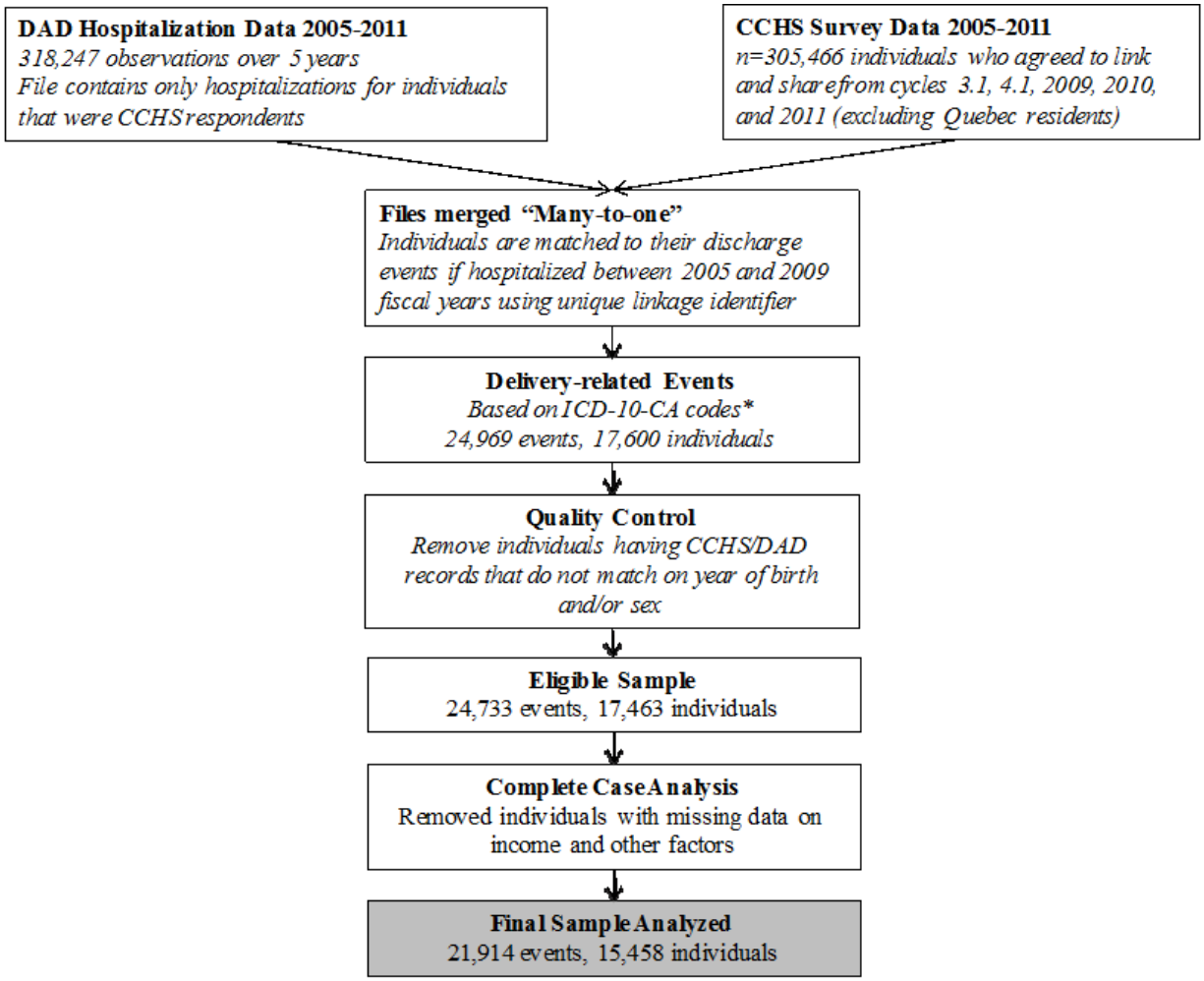
Data Source: Sample used for complete case analysis from CCHS years 2005-2011.

Supplementary Table 2: Descriptive statistics and frequencies of time of day for admission and discharges. (n=15,458 events)

	Admissions		Discharges	
	Frequency	(%)	Frequency	(%)
Number of exact midnight events 00:00	<30	<0.1	<30	<0.1
Number of exact noon events 12:00	40	0.2	498	2.3
# of records ending in –:00 or –:30 (rounding to half hour)	2425	(11.1)	6665	(30.4)
Number of records ending in –:-0 (rounding to the tens)	4739	(21.6)	10780	(49.2)
Most frequent time(s) of day for admission/discharge	06:00	(0.7)	11:00 11:30 13:00	(2.3)

Data Source: DAD 2005-2011.

Supplementary Figure 3: Flow chart detailing the sample selection approach for complete case analysis of delivery-related admissions.



*International Classification of Diseases and related Health Problems (ICD-10-CA). Refer to Supplementary Table 1 for list of ICD-10-CA codes used to identify singleton live births.

Supplementary Table 3: Maternal characteristics of income non-responders

	Frequency (n = 1,931)	(%)
Maternal age*		
≤19 years	233	(12.1)
20-34 years	1,484	(76.9)
≥20 years	214	(11.1)
Number of deliveries between 2005-2011		
1	1,278	(66.2)
2	546	(28.3)
3+	107	(5.5)
Rural area of residence	592	(30.7)
Marital status un-partnered**	811	(42.0)
Aboriginal Status **	317	(16.4)
Immigrant status**	185	(9.6)

* Maternal age at first delivery listed in the dataset, pertaining to those women who had multiple births in hospital between 2005 and 2011.
** a small number of women did not provide responses for these survey items, and are therefore missing from these counts - leading to less than 100% accounted for.
Data Sources: CCHS years 2005-2011; DAD fiscal years 2005-2011.

Supplementary Table 4. Incidence rate ratios and marginal estimates of length of stay (LOS) in hours

Vaginal Delivery (n = 15,902)

	Unadjusted			Adjusted**		
	IRR [95%CI]	P	LOS [95%CI]	IRR [95%CI]	P	LOS [95%CI]
Income						
High	1.00		52.09 [51.28, 52.90]	1.00		52.31 [51.51, 53.11]
Middle	1.01 [0.99, 1.04]	0.348	52.80 [51.55, 54.05]	1.00 [0.97, 1.03]	0.822	52.49 [51.2, 53.78]
Low	1.06 [1.02, 1.09]	0.003*	54.99 [53.22, 56.76]	1.04 [1.00, 1.08]	0.039*	54.53 [52.61, 56.44]
Aboriginal Status						
No	1.00		52.20 [51.51, 52.88]	1.00		52.24 [51.60, 52.89]
Yes	1.07 [1.03, 1.10]	<0.001*	55.68 [53.88, 57.48]	1.06 [1.02, 1.10]	0.003*	55.41 [53.36, 57.46]
Geography						
Urban	1.00		51.46 [50.74, 52.19]	1.00		51.87 [51.17, 52.57]
Rural	1.08 [1.05, 1.12]	<0.001*	55.82 [54.48, 57.17]	1.05 [1.02, 1.09]	<0.001	54.64 [53.21, 56.07]
Province						
ON	1.00	<0.001*	49.05 [48.05, 50.06]	1.00		48.36 [47.33, 49.38]
PE	1.44 [1.37, 1.52]	<0.001*	70.77 [67.45, 74.09]	1.55 [1.47, 1.64]	<0.001*	75.19 [71.53, 78.86]
NS	1.35 [1.24, 1.46]	<0.001*	66.10 [60.97, 71.23]	1.41 [1.30, 1.52]	<0.001*	67.97 [63.00, 72.95]
NB	1.27 [1.22, 1.33]	<0.001*	62.47 [60.22, 64.72]	1.35 [1.29, 1.41]	<0.001*	65.08 [62.62, 67.53]
NL	1.52 [1.43, 1.62]	<0.001*	74.69 [70.23, 79.16]	1.60 [1.50, 1.70]	<0.001*	77.29 [72.64, 81.94]
MB	1.13 [1.09, 1.17]	<0.001*	55.52 [53.89, 57.15]	1.14 [1.09, 1.18]	<0.001*	54.90 [53.24, 56.56]
SK	1.18 [1.13, 1.22]	<0.001*	57.68 [55.90, 59.47]	1.18 [1.14, 1.23]	<0.001*	57.05 [55.28, 58.82]
AB	0.91 [0.87, 0.94]	<0.001*	44.40 [42.83, 45.98]	0.91 [0.88, 0.95]	<0.001*	44.24 [42.74, 45.74]
BC	1.00 [0.96, 1.05]	0.888	49.22 [47.13, 51.32]	1.06 [1.02, 1.11]	0.009	51.43 [49.36, 53.49]
NT/NU/YT	1.18 [1.13, 1.24]	<0.001*	58.03 [55.53, 60.54]	1.16 [1.11, 1.22]	<0.001*	56.19 [53.68, 58.71]
Marital status						
Partnered	1.00		51.65 [50.89, 52.41]	1.00		52.15 [51.38, 52.92]
Not-partnered	1.07 [1.04, 1.10]	<0.001*	55.37 [54.20, 56.54]	1.03 [1.00, 1.06]	0.033*	53.89 [52.58, 55.19]
Immigrant status						
No	1.00		52.77 [52.12, 53.42]	1.00		52.54 [51.91, 53.16]
Yes	0.95 [0.89, 1.01]	0.106	50.09 [46.99, 53.19]	1.02 [0.96, 1.09]	0.531	53.59 [50.33, 56.84]
Primiparous						
No	1.00		48.42 [47.66, 49.18]	1.00		47.74 [46.98, 48.50]
Yes	1.25 [1.23, 1.28]	<0.001*	60.71 [59.63, 61.79]	1.31 [1.27, 1.34]	<0.001*	62.45 [61.25, 63.64]

* Maternal age at first delivery listed in the dataset, pertaining to those women who had multiple births in hospital between 2005 and 2011.

** a small number of women did not provide responses for these survey items, and are therefore missing from these counts - leading to less than 100% accounted for.

Data Sources: CCHS years 2005-2011; DAD fiscal years 2005-2011.

Supplementary Table 4, cont. Incidence rate ratios and marginal estimates of length of stay (LOS) in hours

Caesarian Delivery (n = 6,012)

	Unadjusted			Adjusted**		
	IRR [95%CI]	P	LOS [95%CI]	IRR [95%CI]	P	LOS [95%CI]
Income						
High	1.00		89.55 [87.34, 91.75]	1.00		89.70 [87.37, 92.02]
Middle	1.12 [1.05, 1.20]	0.001*	100.70 [94.50, 106.91]	1.12 [1.04, 1.19]	0.001*	100.07 [94.05, 106.10]
Low	1.00 [0.94, 1.06]	0.95	89.38 [84.81, 93.96]	1.00 [0.93, 1.08]	0.984	89.76 [84.18, 95.34]
Aboriginal Status						
No	1.00		92.02 [89.74, 94.30]	1.00		91.90 [89.69, 94.12]
Yes	1.02 [0.96, 1.08]	0.492	93.94 [88.91, 98.97]	1.04 [0.97, 1.10]	0.263	95.13 [89.76, 100.50]
Geography						
Urban	1.00		90.72 [88.57, 92.86]	1.00		91.34 [89.17, 93.51]
Rural	1.07 [1.00, 1.14]	0.04*	96.91 [91.23, 102.59]	1.04 [0.98, 1.10]	0.235	94.82 [89.45, 100.20]
Province						
ON	1.00		87.08 [83.78, 90.37]	1.00		86.29 [83.00, 89.58]
PE	1.28 [1.14, 1.44]	<0.001*	111.40 [98.76, 124.04]	1.32 [1.17, 1.49]	<0.001*	113.97 [101.15, 126.79]
NS	1.31 [1.14, 1.51]	<0.001*	114.01 [98.49, 129.52]	1.34 [1.17, 1.54]	<0.001*	115.85 [101.19, 130.52]
NB	1.21 [1.06, 1.38]	0.005*	105.36 [91.82, 118.89]	1.25 [1.08, 1.43]	0.002*	107.49 [93.39, 121.59]
NL	1.23 [1.08, 1.40]	0.002*	106.99 [93.85, 120.12]	1.26 [1.12, 1.42]	<0.001*	108.76 [96.98, 120.54]
MB	1.09 [1.01, 1.17]	0.02*	94.77 [89.07, 100.48]	1.08 [1.01, 1.15]	0.031*	93.01 [87.75, 98.27]
SK	1.05 [0.98, 1.13]	0.164	91.62 [86.05, 97.20]	1.05 [0.98, 1.13]	0.162	90.75 [85.31, 96.19]
AB	1.00 [0.93, 1.08]	0.916	87.44 [81.61, 93.26]	1.00 [0.93, 1.08]	0.913	86.64 [81.11, 92.17]
BC	1.06 [0.99, 1.13]	0.09*	92.20 [87.20, 97.20]	1.10 [1.03, 1.18]	0.003*	95.19 [90.28, 100.11]
NT/NU/YT	1.06 [0.98, 1.14]	0.136	91.98 [86.34, 97.62]	1.05 [0.98, 1.13]	0.176	90.64 [84.90, 96.38]
Marital status						
Partnered	1.00		90.82 [88.58, 93.06]	1.00		91.02 [88.71, 93.34]
Not-partnered	1.07 [1.00, 1.13]	0.04*	96.79 [91.42, 102.17]	1.06 [0.98, 1.13]	0.127	96.04 [90.20, 101.88]
Immigrant status						
No	1.00		92.49 [90.27, 94.71]	1.00		92.28 [90.11, 94.46]
Yes	0.95 [0.88, 1.04]	0.260	88.21 [81.24, 95.17]	0.98 [0.90, 1.07]	0.711	90.82 [83.46, 98.19]
Primiparous						
No	1.00		88.41 [85.59, 91.22]	1.00		86.38 [83.61, 89.16]
Yes	1.12 [1.07, 1.17]	<0.001*	98.74 [95.63, 101.85]	1.19 [1.13, 1.25]	<0.001*	102.82 [98.99, 106.66]

* Maternal age at first delivery listed in the dataset, pertaining to those women who had multiple births in hospital between 2005 and 2011.

** a small number of women did not provide responses for these survey items, and are therefore missing from these counts - leading to less than 100% accounted for.

Data Sources: CCHS years 2005-2011; DAD fiscal years 2005-2011.

Supplementary Table 5: Odds ratios and risks of maternal admission within 30 days before delivery

Risk of pre-delivery admission for all deliveries (n=21,914)

	Unadjusted			Adjusted**		
	OR [95%CI]	P	Predicted risk [95%CI]	OR [95%CI]	P	Predicted risk [95%CI]
Income						
High	1.00		0.04 [0.03, 0.04]	1.00		0.04 [0.03, 0.04]
Middle	1.46 [1.25, 1.70]	<0.001*	0.05 [0.05, 0.06]	1.31 [1.11, 1.54]	0.002*	0.05 [0.04, 0.05]
Low	1.80 [1.48, 2.20]	<0.001*	0.06 [0.05, 0.07]	1.43 [1.13, 1.81]	0.003*	0.05 [0.04, 0.05]
Aboriginal Status						
No	1.00		0.04 [0.04, 0.04]	1.00		0.04 [0.04, 0.04]
Yes	1.87 [1.57, 2.24]	<0.001*	0.07 [0.06, 0.08]	1.34 [1.09, 1.67]	0.007*	0.05 [0.04, 0.06]
Geography						
Urban	1.00		0.04 [0.04, 0.04]	1.00		0.04 [0.04, 0.05]
Rural	1.16 [1.00, 1.35]	0.056	0.05 [0.04, 0.05]	1.01 [0.86, 1.18]	0.914	0.04 [0.04, 0.05]
Marital status						
Partnered	1.00		0.04 [0.04, 0.04]	1.00		0.04 [0.04, 0.05]
Not-partnered	1.24 [1.06, 1.44]	0.006*	0.05 [0.04, 0.06]	0.97 [0.81, 1.17]	0.764	0.04 [0.04, 0.05]
Immigrant status						
No	1.00		0.04 [0.04, 0.05]	1.00		0.04 [0.04, 0.05]
Yes	0.51 [0.36, 0.72]	<0.001*	0.02 [0.02, 0.03]	0.62 [0.43, 0.88]	0.007*	0.03 [0.02, 0.04]
Province						
ON	1.00		0.02 [0.02, 0.03]	1.00		0.03 [0.02, 0.03]
PE	1.10 [0.60, 2.01]	0.761	0.03 [0.01, 0.04]	1.05 [0.57, 1.93]	0.872	0.03 [0.01, 0.04]
NS	2.96 [2.18, 4.02]	<0.001*	0.07 [0.05, 0.09]	2.80 [2.05, 3.82]	<0.001*	0.07 [0.05, 0.09]
NB	2.33 [1.69, 3.21]	<0.001*	0.06 [0.04, 0.07]	2.21 [1.61, 3.05]	<0.001*	0.05 [0.04, 0.07]
NL	3.60 [2.62, 4.95]	<0.001*	0.08 [0.06, 0.10]	3.35 [2.42, 4.64]	<0.001*	0.08 [0.06, 0.10]
MB	2.85 [2.25, 3.60]	<0.001*	0.07 [0.05, 0.08]	2.42 [1.90, 3.09]	<0.001*	0.06 [0.05, 0.07]
SK	2.94 [2.34, 3.68]	<0.001*	0.07 [0.06, 0.08]	2.55 [2.02, 3.22]	<0.001*	0.06 [0.05, 0.07]
AB	1.30 [1.01, 1.67]	0.04*	0.03 [0.03, 0.04]	1.27 [0.99, 1.63]	0.057	0.03 [0.03, 0.04]
BC	2.34 [1.88, 2.91]	<0.001*	0.06 [0.05, 0.06]	2.33 [1.87, 2.91]	<0.001*	0.06 [0.05, 0.07]
NT/NU/YT	2.19 [1.54, 3.12]	<0.001*	0.05 [0.04, 0.07]	1.67 [1.14, 2.46]	0.009	0.04 [0.03, 0.06]
Primiparous						
No	1.00		0.04 [0.04, 0.05]	1.00		0.04 [0.04, 0.05]
Yes	0.88 [0.76, 1.01]	0.063	0.04 [0.03, 0.04]	1.04 [0.89, 1.23]	0.598	0.04 [0.04, 0.05]

* $P < 0.05$

** adjusted models include the five maternal socio-demographic variables in addition to household size, primiparity, province of delivery, year of delivery, and maternal age at delivery.

Data Sources: CCHS years 2005-2011; DAD fiscal years 2005-2011.

Supplementary Table 6: Odds ratios and risks of maternal readmission within 30 days of delivery

Risk of readmission for vaginal delivery (n = 15,902)

	Unadjusted			Adjusted**		
	OR [95%CI]	P	Predicted risk [95%CI]	OR [95%CI]	P	Predicted risk [95%CI]
Income						
High	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Middle	1.29 [0.92, 1.80]	0.146	0.01 [0.01, 0.02]	1.16 [0.80, 1.67]	0.439	0.01 [0.01, 0.02]
Low	1.42 [0.91, 2.21]	0.126	0.01 [0.01, 0.02]	1.08 [0.64, 1.81]	0.77	0.01 [0.01, 0.02]
Aboriginal Status						
No	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Yes	1.86 [1.26, 2.73]	0.002*	0.02 [0.01, 0.03]	1.58 [0.97, 2.56]	0.066	0.02 [0.01, 0.02]
Geography						
Urban	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Rural	1.14 [0.82, 1.58]	0.441	0.01 [0.01, 0.02]	1.06 [0.75, 1.51]	0.737	0.01 [0.01, 0.02]
Marital status						
Partnered	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Not-partnered	1.38 [1.01, 1.89]	0.046*	0.01 [0.01, 0.02]	1.29 [0.89, 1.86]	0.18	0.01 [0.01, 0.02]
Immigrant status						
No	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Yes	1.01 [0.56, 1.82]	0.975	0.01 [0.01, 0.02]	1.16 [0.62, 2.17]	0.635	0.01 [0.01, 0.02]
Province						
ON	1.00		0.01 [0.00, 0.01]	1.00		0.01 [0.01, 0.01]
PE	1.55 [0.48, 5.02]	0.465	0.01 [0.00, 0.02]	1.53 [0.46, 5.06]	0.485	0.01 [0.00, 0.02]
NS	3.16 [1.72, 5.80]	<0.001*	0.02 [0.01, 0.03]	3.01 [1.60, 5.67]	0.001*	0.02 [0.01, 0.03]
NB	1.93 [0.94, 3.96]	0.075	0.01 [0.00, 0.02]	1.96 [0.94, 4.13]	0.074	0.01 [0.00, 0.02]
NL	1.21 [0.44, 3.36]	0.712	0.01 [0.00, 0.02]	1.13 [0.41, 3.12]	0.814	0.01 [0.00, 0.02]
MB	2.88 [1.75, 4.73]	<0.001*	0.02 [0.01, 0.03]	2.46 [1.45, 4.18]	0.001*	0.02 [0.01, 0.02]
SK	1.95 [1.15, 3.33]	0.014*	0.01 [0.01, 0.02]	1.77 [1.01, 3.10]	0.048*	0.01 [0.01, 0.02]
AB	1.61 [0.98, 2.63]	0.059	0.01 [0.01, 0.02]	1.64 [1.00, 2.69]	0.048*	0.01 [0.01, 0.02]
BC	2.13 [1.31, 3.47]	0.002*	0.01 [0.01, 0.02]	2.14 [1.32, 3.47]	0.002*	0.02 [0.01, 0.02]
NT/NU/YT	1.81 [0.85, 3.85]	0.123	0.01 [0.00, 0.02]	1.32 [0.59, 2.97]	0.5	0.01 [0.00, 0.02]
Primiparous						
No	1.00		0.01 [0.01, 0.01]	1.00		0.01 [0.01, 0.01]
Yes	1.00 [0.73, 1.36]	0.989	0.01 [0.01, 0.01]	1.17 [0.83, 1.66]	0.377	0.01 [0.01, 0.02]

* $P < 0.05$

** adjusted models include the five maternal socio-demographic variables in addition to household size, primiparity, province of delivery, year of delivery, and maternal age at delivery.

Data Sources: CCHS years 2005-2011; DAD fiscal years 2005-2011.

Supplementary Table 6 cont.: Odds ratios and risks of maternal readmission within 30 days of delivery

Risk of readmission for Caesarian Delivery (n = 6,012)

	Unadjusted			Adjusted**		
	OR [95%CI]	P	Predicted risk [95%CI]	OR [95%CI]	P	Predicted risk [95%CI]
Income						
High	1.00		0.02 [0.01, 0.02]	1.00		0.02 [0.01, 0.02]
Middle	1.42 [0.94, 2.14]	0.093	0.02 [0.02, 0.03]	1.22 [0.75, 1.99]	0.419	0.02 [0.01, 0.03]
Low	2.35 [1.44, 3.83]	0.001*	0.04 [0.02, 0.06]	1.80 [0.98, 3.27]	0.056	0.03 [0.02, 0.05]
Aboriginal Status						
No	1.00		0.02 [0.02, 0.02]	1.00		0.02 [0.02, 0.02]
Yes	2.12 [1.32, 3.40]	0.002*	0.04 [0.02, 0.06]	1.87 [1.12, 3.12]	0.017*	0.04 [0.02, 0.05]
Geography						
Urban	1.00		0.02 [0.02, 0.03]	1.00		0.02 [0.02, 0.03]
Rural	0.60 [0.37, 0.97]	0.036*	0.01 [0.01, 0.02]	0.49 [0.30, 0.80]	0.004*	0.01 [0.01, 0.02]
Marital status						
Partnered	1.00		0.02 [0.01, 0.02]	1.00		0.02 [0.02, 0.03]
Not-partnered	1.64 [1.12, 2.39]	0.01*	0.03 [0.02, 0.04]	1.04 [0.66, 1.64]	0.873	0.02 [0.01, 0.03]
Immigrant status						
No	1.00		0.02 [0.02, 0.03]	1.00		0.02 [0.02, 0.03]
Yes	0.54 [0.22, 1.33]	0.182	0.01 [0.00, 0.02]	0.64 [0.26, 1.60]	0.339	0.01 [0.00, 0.03]
Province						
ON	1.00		0.02 [0.01, 0.02]	1.00		0.02 [0.01, 0.02]
PE	1.75 [0.63, 4.86]	0.279	0.03 [0.00, 0.06]	2.01 [0.74, 5.42]	0.169	0.04 [0.00, 0.07]
NS	1.96 [0.94, 4.08]	0.072	0.03 [0.01, 0.06]	1.87 [0.87, 4.02]	0.111	0.03 [0.01, 0.06]
NB	2.04 [1.02, 4.08]	0.044*	0.04 [0.01, 0.06]	2.22 [1.10, 4.49]	0.026*	0.04 [0.02, 0.06]
NL	1.61 [0.71, 3.64]	0.25	0.03 [0.01, 0.05]	1.50 [0.65, 3.49]	0.346	0.03 [0.01, 0.05]
MB	1.19 [0.56, 2.56]	0.652	0.02 [0.01, 0.04]	1.03 [0.47, 2.26]	0.933	0.02 [0.01, 0.03]
SK	1.66 [0.90, 3.05]	0.104	0.03 [0.01, 0.04]	1.40 [0.74, 2.65]	0.301	0.03 [0.01, 0.04]
AB	0.75 [0.38, 1.46]	0.4	0.01 [0.01, 0.02]	0.72 [0.37, 1.42]	0.345	0.01 [0.01, 0.02]
BC	1.07 [0.60, 1.91]	0.827	0.02 [0.01, 0.03]	1.01 [0.57, 1.79]	0.971	0.02 [0.01, 0.03]
NT/NU/YT	1.57 [0.55, 4.44]	0.396	0.03 [0.00, 0.05]	1.20 [0.41, 3.49]	0.734	0.02 [0.00, 0.04]
Primiparous						
No	1.00		0.02 [0.02, 0.02]	1.00		0.02 [0.02, 0.02]
Yes	1.18 [0.83, 1.69]	0.36	0.02 [0.02, 0.03]	1.19 [0.80, 1.78]	0.395	0.02 [0.02, 0.03]

* $P < 0.05$

** adjusted models include the five maternal socio-demographic variables in addition to household size, primiparity, province of delivery, year of delivery, and maternal age at delivery.

Data Sources: CCHS years 2005-2011; DAD fiscal years 2005-2011.